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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Wide Angle Zoom Lens System

We, CANON CAMERA COMPANY INCORPORATED, a corporation duly organised under the laws of Japan having its principal place of business at 312, Shimomarukocho, Ohta-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a wide angle zoom lens system suitable for television cameras or the like, which is well corrected for aberrations throughout the whole zooming range, especially at the greater zoom ratios.

In known zoom lens systems of the type used for three tube colour television cameras, a very complicated optical system was required wherein an image is formed by the shooting lens on, or in the proximity of, a field lens and then transmitted by a relay lens system on to the camera tube surface. For the four tube separate luminance television camera, an even more complicated optical system was required. Such systems are also inconvenient in as much as the field lens must be exchanged each time the shooting lens is exchanged. Moreover, zoom lenses, expecially those used for television where it is often required to make an image of a small article cover the whole field of view, are required to have a very short minimum distance of shooting and therefore a large zoom ratio. This requirement is relatively incompatible with the requirement of good correction for various aberrations, and it has hithertofore been next to impossible to satisfy both such requirements.

Furthermore, an additional zoom lens system has been necessary for use in television studios since there has been no high speed zoom lens system throughout its zoom range and whose zoom range is of a sufficiently wide region that the field angle is more than 50° in its shortest focal length condition.

It is an object of the invention to provide a wide angle zoom lens system which over its entire zoom range has a back focal length more than five times as large as the focal length in its shortest focal length adjustment. With such sufficient back focal length, the zoom lens system of the invention when used in three tube colour television cameras is capable of forming an image directly on the image orthicon without using any relay lens system, whereby each channel can afford to share the light flux. Also when used as a usual zoom lens, the field lens does not require inter-changing since the position of the exit pupil is maintained constant regardless of the variation of the focal length.

Usually, to achieve the same purpose, an extremely retrofocus type of lens system results, because the rear principal point must exist far behind the lens system in its shortest focal length position with deterioration in the various aberrations, especially the Petzval sum, to such an extent that their correction becomes difficult even with a single focal length lens, not to say anything about a zoom lens. The present invention has overcome such difficulty.

It is another object of the invention to provide a wide angle zoom lens system which has its minimum distance of shooting less than five times the focal length at its longest focal length position, while retaining a zoom ratio of about ten magnifications.

In order to maintain the F number constant within the whole zoom range, the light flux focussed in the image plane on the optical axis should have a cross-sectional diameter (2p) expressed by the formula $2p=f_z/F$ in a plane tangential to the front lens surface, where f_z is the focal length for each zoom position Z. In the preferred embodiment of the present invention, since the zoom ratio is ten magnifications, f_z varies by a factor of ten and hence p also varies by a factor of ten. On the other hand, a zoom lens should be of the front lens focussing type in

order to satisfy a certain zoom equation for all distances of shooting. Unless F_F, the F number of the front focussing lens, is defined by $F_F = f_F/2P_{max}$, where f_F denotes the focal length of the front focussing lens and $2P_{max}$ denotes the maximum of 2P the diameter of the front focussing lens, is above a certain value, it is not possible to correct for various aberrations, such as spherical aberration. Therefore it should be that $f_F >> f_{min}$, where f_{min} is the minimum value of f_z. It is noted that the amount of movement of the front lens for focussing is proportional to $(f_F)^2$ and therefore, is far greater than the amount of movement of a single lens with focal length f_{min} which is proportional to $(f_{min})^2$, and yet the same field angle is obtained when the focal length of the zoom lens is f_{min}. In order to avoid vignetting in the marginal area of the field for all values of f_z whilst permitting a large amount of movement proportional to $(f_F)^2$, the diameter of the focussing lens must be chosen to be very much greater for objects at short distances.

It is a further object of the invention to provide a wide angle zoom lens system which has a high zoom ratio in the order of 10 while continuously maintaining an aperture of F:4, and whose zoom range lies within a wide range with the field angle more than 50° at the shortest focal length position, whereby the necessity for using two lenses in television studios can be eliminated.

It is a still further object of the invention to provide a wide angle zoom lens system which is well corrected for various aberrations throughout its zoom range whilst simultaneously fulfilling the three objects mentioned above.

According to the invention there is provided a high aperture and wide angle zoom lens system having a short minimum distance of shooting and a long back focal length at the upper limit of a higher zoom ratio and wider field of view, comprising six lens groups, namely, a focussing lens group consisting of a divergent lens system movable only for focussing independently of zooming, a front lens group consisting of a stationary converging lens system, a variator lens group comprising a diverging lens system movable in the axial direction, a compensator lens group comprising a divergent lens system movable in conjunction with the variator for maintaining the position of the focal plane of the lens system constant throughout the zoom range, and a first and a second rear lens group, each comprising a stationary converging lens system, said zoom lens system satisfying the following conditions:

The aperture stop of the whole system is located in front of the first rear lens group as close to the compensator lens group as possible so as not to interfere mechanically with the latter; the focal length of the first rear lens group is so chosen that the equivalent focal length of the lens groups from the focussing lens group to the first rear lens group is always negative throughout the zoom range, while its absolute value at the shortest focal length position of such lens groups is 1.5 to 2.5 times the focal length of the whole system at the shortest focal length position of the lens group of the whole zoom lens system; the absolute value of the focal length of the variator lens group is in a range of 2.2 to 1.6 times the focal length of the whole zoom lens system at the shortest focal length position of the zoom system lens groups; the focal length of the focussing lens is negative, its absolute value being less than 1/1.3 of the focal length of the whole zoom lens system at the longest total focal length position of all its lens groups; the front lens group has a positive focal length whose absolute value is less than 1./1.3 of the absolute focal length of the focussing lens, the spacing between the second principal point of Group I and the first principal point of Group II being 0.23 to 0.33 of the focal length of the whole zoom lens system with all its lens groups in the position giving the longest focal length of the system; the equivalent focal length of the focussing and the front lens groups combined is between 3/5 of and equal to the focal length of the whole system at the longest focal length position of its lens groups; the refractive index of the glass of each lens of the variator lens group is more than 1.8; the refractive index of the glass for the compensator lens group more than 1.7; the refractive index of the negative single lenses of the focussing lens group is more than 1.65; the refractive index of the positive single lenses of the front lens group is less than 1.55; the refractive index of each positive single lens of the first rear lens group is less than 1.55; the front lens group includes at least two negative single lenses, their differences in Abbe number from the positive single lenses of the front lens group being greater than 35; the negative and positive lenses of the front lens group are cemented together respectively a negative to a positive lens such that the centers of curvature of the cemented surfaces are located at the point on the optical axis which are on the same side of the cemented surface as the point at which a marginal light ray incident upon the cemented surface and which reaches the centre of the image surface, or the extension of such a ray, crosses the axis; and the first rear lens group consists of at least one separate positive simple lens and at least one negative simple lens, there being in the second rear lens at least two doublets of positive and negative lenses of biconvex form of which each cemented interface of the doublets is divergent and its center of curvature is

located on the side opposite the stop from the point at which said interface crosses the optical axis.

A preferred embodiment of the invention will now be described with reference to the accompanying drawings in which:—

Figure 1 is an axial sectional representation of a wide angle zoom lens system in accordance with the invention; and

Figures 2—4 are diagrams showing the aberration correction at three different conditions of zooming.

Referring to Figure 1, a zoom lens system in accordance with the invention is shown comprising six groups of lenses, I to VI, respectively.

The front lens combination consists of the first group I and the second group II. The first group I is a focussing lens group comprising a divergent lens system which is stationary during zooming but is moved to focus the lens regardless of the zoom position. This lens group will hereinafter be referred to as the " focussing " lens I.

The second group II is a converging lens system and is stationary.

The third group III is a diverging lens system and constitutes a " variator " that is movable, through a large stroke in the axial direction, to vary the magnification of the whole lens system.

The fourth group IV is a diverging lens system and constitutes a " compensator " that is moved simultaneously with the third group III to maintain the position of the focal plane constant throughout the zoom range.

The fifth group V is a stationary converging lens system and will hereinafter be referred to as the " first rear lens."

The sixth group VI is a stationary converging lens system and will hereinafter be referred to as the " second rear lens."

The above zoom lens system is constructed to satisfy the following five conditions:

(1) An aperture stop AS in the complete system is positioned in front of the first rear lens V, as close to the compensator IV as possible, but must not interfere mechanically with it. The focal length of the first rear lens V is so chosen that the equivalent focal length, of lens groups I to V combined, will always be negative throughout the zoom range and the absolute value of said focal length at the shortest focal length position will be 1.5→2.5 times the focal length, f_{min}, of the complete zoom lens system at its shortest focal length position. Furthermore the focal length f_{III} of the variator III is chosen so as to be in a range of 2.2→1.6 times f_{min}.

(2) The focussing lens group I has a negative focal length f_F whose absolute value is less than 1/1.3 of the focal length f_{max} of the complete zoom lens system at its longest focal length position. The lens group II has a positive focal length f_{fr}, its absolute value being less than 1/1.3 of $|f_F|$ and the spacing between the second principal point of group I and the first principal point of group II being $(0.23\rightarrow0.33)f_{max}$. The equivalent focal length of front lenses I and II combined is in the range of $(3/5\rightarrow1)f_{max}$.

(3) The refractive index of the glass of each lens comprising the variator lens group III is greater than 1.8, and that of the glass of each lens of the compensator IV is greater than 1.7. The refractive index of each of the negative single lenses belonging to the lenses making up the focussing lens I is greater than 1.65, and that of the each positive single lens belonging to the lenses making up the front lens II is less than 1.55. The refractive index of each of the positive single lenses of the rear first lens is less than 1.55.

(4) In the lens group II, at least two negative single lenses are included and the difference in their Abbe number from those of the positive single lenses in the group, is at least 35.

These negative lenses are each cemented together with a respective one of the positive lenses such that the centers of curvature of the cemented surfaces are located at the points on the optical axis which are on the same side of the cemented surface as the point at which a marginal light ray incident upon the cemented surface and which reaches the centre of the image surface, or the extension of such a ray, crosses the axis.

(5) The first rear lens V is composed of at least a separate simple positive lens and at least one simple negative lens. In the second rear lens VI there are at least two doublets of positive and negative lenses of biconvex form, the cemented interface of each doublet being divergent, with its center of curvature being located to the opposite side of the stop from the point at which said interface crosses the optical axis.

The zoom lens system in accordance with this invention is constructed in accordance with the foregoing conditions and reference will now be made to its functions:

(A) In order to have the stop aperture AS position fixed and to maintain the F-value of the whole lens system constant, independently of the zoom position, it is necessary that the stop should be disposed behind all of the movable lenses, and as close to the focussing lens as possible, for the purpose of aberration correction and to reduce the diameters of the focussing lens I and of the front lens II. In the present invention the position of the stop is determined by this condition.

To obtain a long back focal length, the first to the fifth groups of lenses I—V must be formed as negative lenses, with the second rear lens VI as a positive lens system, and both combined should form a retrofocus type

positive lens system. In order to achieve proper control of the aberration correction, especially of the Petzval sum, the first rear lens V should be positioned close to the stop, so that the light flux concentrating to the axial object point may cross the lens surface at a lower point at the position of lens V, and at a higher point at the position of the rear second lens VI, as measured from the optical axis.

It is also a requirement that the refractive power and the spacings between the principal points of both lens systems V and VI be appropriately determined to accommodate the entire system within a suitable size and to correct for aberrations such as Petzval sum or the like within suitable limits.

It is important to select a proper focal length of the variator for the purpose of correcting for aberrations, particularly for the Petzval sum.

(B) As H. H. Hopkins says in the Proceedings of the London Conference on Optical Instruments, 1950, pp. 17—32, a zoom lens system with a single variator is suitable for use as a lens of a high zoom ratio, when the single variator is a diverging lens system, preceded by a stationary converging lens system. In the prior art, however, where the variator is preceded by a group of converging lenses which is stationary during zooming and movable only during focussing, the selection of the focal length and the amount of movement involves such difficulty as mentioned before in connection with the second object of the present invention that it is not practically possible to focus up to a short object distance point.

In accordance with the present invention, the lens system disposed ahead of the variator III which stays stationary during zooming, is divided into two groups I and II which combinedly provide a converging lens system, of which the front lens group I is a diverging lens system and the rear group II is a converging lens system, with proper relationship between the refractive powers of lens groups I and II. Thus, with the combined system of groups I and II being a positive lens system and the third group, the variator III, being a negative lens system, a lens system of high zoom ratio is provided, retaining the advantages reported by H. H. Hopkins.

Moreover, the use of a diverging lens, (group I in the present invention) as the focussing lens presents two additional advantages. One of the advantages is that less movement is needed to focus a short distance object point as compared with a positive lens having the same focal length, since the first focal point of the lens system of group I is, unlike a positive lens system, on the opposite side from the object point. The other is that the increase in the effective aperture of the first group I required to avoid vignetting in the marginal portion of the field, is smaller for a given amount of movement as compared to a positive lens system since the ray entering at a large angle to the optical axis and leading to the marginal part of the field will be bent to a smaller angle by the negative lens system. As the focal length of the system is shortened, this advantage will become greater, but the Petzval sum will be shifted negative and the aberration correction will become difficult. Besides, if the ratio of the focal length of the focussing lens I, to that of the front lens II, is not taken properly, the effective aperture of one of them will be too much greater than that of the other.

The conditions required for correction of these aberrations and proper maintenance of the focal lengths of the two lens groups are the aforementioned condition (2) in accordance with the invention given to the refractive power and principal point spacing.

(C) A zoom lens of a great zoom ratio made under the conditions (1) and (2) as mentioned before would suffer a considerable shift of Petzval sum toward negative. In order to avoid this, it is necessary to select a very high value of refractive index for each of the glasses of the variator which has the most intense diverging power in the complete system (this is determined by the zoom equation and conditions (1) and (2) above), and to select a high value of refractive index for the glass of the compensator and for the focussing lens which has the next strongest diverging power, and to select a low value of refractive index for the single lenses that have strong positive power. These are satisfied by condition (3), stated above.

(D) As stated in connection with the second object of this invention, P_{max} would be very great in a zoom lens of high zoom ratio. If the condition (2) is satisfied, the marginal ray of the light flux going to the center of the field will cross the refractive surface of the front lens at a point spaced from the optical axis, and the front lens will have a stronger positive refractive power compared with the case where a one-group positive lens system is positioned preceding the variator as in the prior art, while, on the other hand, the path taken by the light flux in the lens groups I and II going to the same point in the field, will vary during zooming. Therefore, unless these two lens groups I and II are almost perfectly achromatised separately, considerable chromatic spherical aberration will be produced at the longest focal length zoom position as well as a variation in the magnification of chromatic aberration due to zooming. These problems are eliminated when the previously mentioned condition (4) is fulfilled. Cementing the positive and negative lenses together is preferred, though not essential, to

avoid the effect of grinding errors and to realise the performance as estimated by design.

(E) The path through the focussing lens I, the front lens II, the variator III and in the compensator IV, taken by the light flux to arrive at the same point in the image field, varies during zooming, while in both the rear first lens V and the rear second lens VI it does not.

It is therefore necessary that the variation of aberrations, due to zooming, be eliminated in the first mentioned four groups, and the constant deviation of aberration from a desired value be eliminated in the two last mentioned groups. The condition (5) is provided to meet such requirements. Since the first rear lens V is positioned close to the stop AS, its coefficient of the third order astigmatism is nearly constant regardless of the lens forms and cannot be controlled by means of the first rear lens V, once its refractive power has been determined on the basis of aberration theory. To cancel the deviation of astigmatism in lens groups I to V, the second rear lens VI provides for the control of the coefficient of astigmatism as it is spaced from the stop. It is only necessary that there be at least one divergent surface in the second rear lens group VI that has its center of curvature on the side away from the stop as seen from the point of intersection of the surface with the optical axis. Usually this is achieved by introducing into the second rear lens group a thick meniscus lens of relatively small refractive power, which also serves to correct the deviation of distortion from the desired value.

This results, however, in a decrease of the back focal length of the whole system and a negative deviation of the Petzval sum to such an extent that the purpose of this invention may not be achieved. These problems have been solved, however, by giving the condition (5) to the rear lens groups V and VI. Correction of chromatic aberration with a set of cemented lenses is possible by proper choice of their Abbe number, and correction of astigmatism and distortion from their desired values with a single cemented divergent interface is possible by proper choice of the difference in refractive indices between its two constituent lens elements and of the difference in their respective radii of curvature. But the resulting spherical aberrations and coma cannot be corrected by the first rear lens V, and it is for this reason that the two pairs of cemented lenses are required.

Although, by proper design of the second rear lens group VI, as stated above, it is possible to avoid deviations from the desired values of aberrations, such as distortion, astigmatism appearing mainly around the marginal parts of the field, the remaining aberrations around the central part of the field, spherical aberration and coma, must be corrected by the first rear lens group V for their deviations from the desired values. Fortunately, since the first rear lens group V is located in the proximity of the stop AS and comprises two groups of separate positive and negative lenses, they have the freedom to correct simultaneously both spherical aberration and coma without substantial disturbance of the astigmatic aberration and distortion.

Thus, by fulfilling the aforementioned condition (5), deviation of all aberrations from their desired value may be corrected.

Shown below is Table 1 of data for an illustrative embodiment of the invention shown in Figure 1. It is to be noted that in this embodiment the aberration correction is provided with a parallel surface, equivalent to such group of parallel surfaces required to divide light flux for use in a colour television and it should be understood that the condition for the back focal length stated in regard to the first mentioned object of the invention is applicable in the absence of such equivalent parallel plane.

The value of the above mentioned back focal length is 292 mm., and the value of the equivalent focal length of the groups I—V in the shortest focal length position is -72.5 mm., whilst f min is 39.5 mm., thus the absolute value of said focal length at the shortest focal length position is $72.5/39.5 = 1.84$ which is in accordance with condition 1). The spacing between the principal points of lens group II is 22 mm. The spacing between the second principal point of lens group I and the first principal point of lens group II is 118 mm., thus condition 2), i.e. that the spacing must be within the range 0.23 f max $-$0.33 f max, is fulfilled using the value of f max of 375.96 mm, as given in the following Table 2. The shortest distance for focussing is 1.5 meters from the front surface of the front lens and the aperture is F4. Table 1 shows the constructional data of the preferred zoom lens system in accordance with the invention.

TABLE I

Composite f	f	Group	r No.	r value	d	n_d	v
						1.0	
236.7	—260	I	1	947.50268	5.0	1.713	53.9
			2	305.84	11.264	1.0	
			3	− 1975.0	5.0	1.713	53.9
			4	610.0	8.645	1.0	
			5	− 652.48	10.0	1.67003	47.2
			6	171.74	16.0	1.72825	28.3
			7	∞	62.772725	1.0	
	180.1	II	8	− 308.57	6.0	1.7552	27.5
			9	− 1905.8	21.0	1.48749	70.0
			10	− 162.48	0.1	1.0	
			11	1229.45	10.0	1.48749	70.0
			12	− 379.98	0.1	1.0	
			13	340.42	10.0	1.48749	70.0
			14	− 1975.0	0.1	1.0	
			15	169.98	15.0	1.48749	70.0
			16	2633.33	4 0	1.7552	27.5
			17	405.8509	d17	1.0	
	—77	III	18	372.49	7.0	1.92286	20.9
			19	− 118.53	2.0	1.841	43.2
			20	118.53	4.208	1.0	
			21	− 618.65	2.0	1.883	41.0
			22	262.8	4.405	1.0	
			23	− 134.77	2.0	1.883	41.0
			24	− 369.15045	d24	1.0	
	—192.5	IV	25	− 103.94	5.0	1.757	47.7
			26	255 71	5.0	1.78472	25.7
			27	− 413 00332	d27	1.0	
	229.27	V	28	213 51	6.5	1.48749	70 0
			29	− 106.76	2.5	1.0	
			30	− 63.19	2.0	1.80518	25.5
			31	− 79.19153	176.29316	1.0	
	191.78	VI	32	∞	2.0	1.66446	35.9
			33	243.56	8.5	1.4645	65.7
			34	− 194.83	0.1	1.0	
			35	495.75	2.0	1.66446	35.9
			36	163.1	8.5	1.4645	65.7
			37	− 321.82	0.1	1.0	
			38	409.09	5.7	1.62041	60.3
			39	− 1039.3723	50.0	1.0	
			40	∞	82.2	1.51633	64.1
			41	∞			

TABLE 2

	effective field surface 40 mm ϕ		
d \ f	39.5	164.70	375.96
d17	3.7540141	164.30958	216.35120
d24	217.29270	31.423073	4.6955089
d27	6.8377210	32.151784	6.8377210

Table 2 shows respectively the air spacings between the front lens II and the variator III, the variator and the compensator IV, and the compensator IV and the first rear lens V, at three different zooming steps corresponding to focal lengths of 39.5, 164.70 and 375.96 milimeters. In tables 1 and 2, f denotes focal length, ν subscript denotes the radii of curvature of the successive lens element surfaces from object to image side, d subscript the thickness of and air spacings between successive lenses along the optical axis, n subscript the refractive indices of respective materials for the d-line of the spectrum, and ν subscript the Abbe number of optical material.

Figures 2—4 show the aberration graphs for the preferred embodiment of Fig. 1. As can be seen from these, the subject-matters stated in connection with the objects of the invention are well realised.

In Figures 2—4, the symbols are as follows:

d; the aberration with respect to the d-line of the spectrum

g; the aberration with respect to the g-line of the spectrum,

M; the meridional curvature, and

S; the sagittal curvature.

WHAT WE CLAIM IS:—

1. A high aperture and wide angle zoom lens system having a short minimum distance of shooting and a long back focal length at the upper limit of a higher zoom ratio and wider field of view, comprising six lens groups, namely, a focussing lens group consisting of a divergent lens system movable only for focussing independently of zooming, a front lens group consisting of a stationary converging lens system, a variator lens group comprising a diverging lens system movable in the axial direction, a compensator lens group comprising a divergent lens system movable in conjunction with the variator for maintaining the position of the focal plane of the lens system constant throughout the zoom range, and a first and a second rear lens group, each comprising a stationary converging lens system, said zoom lens system satisfying the following conditions:

The aperture stop of the whole system is located in front of the first rear lens group as close to the compensator lens group as possible so as not to interfere mechanically with the latter; the focal length of the first rear lens group is so chosen that the equivalent focal length of the lens groups from the focussing lens group to the first rear lens group is always negative throughout the zoom range, while its absolute value at the shortest focal length position of such lens groups is 1.5 to 2.5 times the focal length of the whole system at the shortest focal length position of the lens groups of the whole zoom lens system; the absolute value of the focal length of the variator lens group is in a range of 2.2 to 1.6 times the focal length of the whole zoom lens system at the shortest focal length position of the zoom system lens groups, the focal length of the focussing lens is negative, its absolute value being less than 1/1.3 of the focal length of the whole zoom lens system at the longest total focal length position of all its lens groups, the front lens group has a positive focal length whose absolute value is less than 1/1.3 of the absolute focal length of the focussing lens, the spacing between the second principal point of Group I and the first principal point of Group II being 0.23 to 0.33 of the focal length of the whole zoom lens system with all its lens groups in the position giving the longest focal length of the system, the equivalent focal length of the focussing and the front lens groups combined is between 3/5 of and equal to the focal length of the whole system at the longest focal length position of its lens group; the refractive index of the glass of each lens of the variator lens group is more than 1.8; the refractive index of the glass for the compensator lens group more than 1.7; the refractive index of the negative single lenses of the focussing lens group is more than 1.65; the refractive index of the positive single

lenses of the front lens group is less than 1.55; the refractive index of each positive single lens of the first rear lens group is less than 1.55; the front lens group includes at least two negative single lenses; their differences in Abbe number from the positive single lenses of the front lens group being greater than 35; each negative lens of the front lens group being cemented to a positive lens such that the centers of curvature of the cemented surfaces are located at the points on the optical axis which are on the same side of the cemented surface as the point at which a marginal light ray incident upon the cemented surface and which reaches the centre of the image surface or the extension of such a ray, crosses the axis; and the first rear lens group consists of at least one separate positive simple lens and at least one negative simple lens, there being in the second rear lens at least two doublets of positive and negative lenses of biconvex form of which each cemented interface of the doublets is divergent and its center of curvature is located on the side opposite the stop from the point at which said interface crosses the optical axis.

2. A wide angle zoom lens system as claimed in Claim 1, substantially as described with reference to tables 1 and 2 in the accompanying text.

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FIG. 1

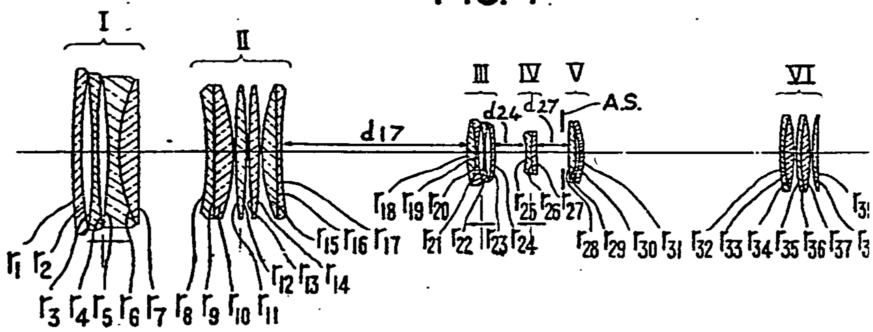
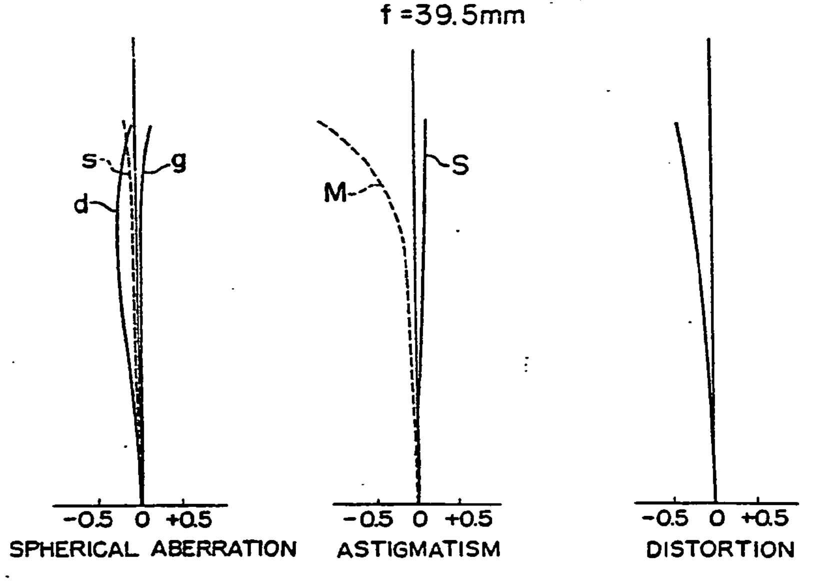


FIG. 2
f =39.5mm



1126069 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

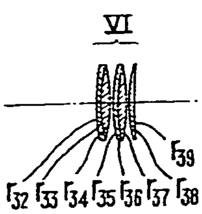
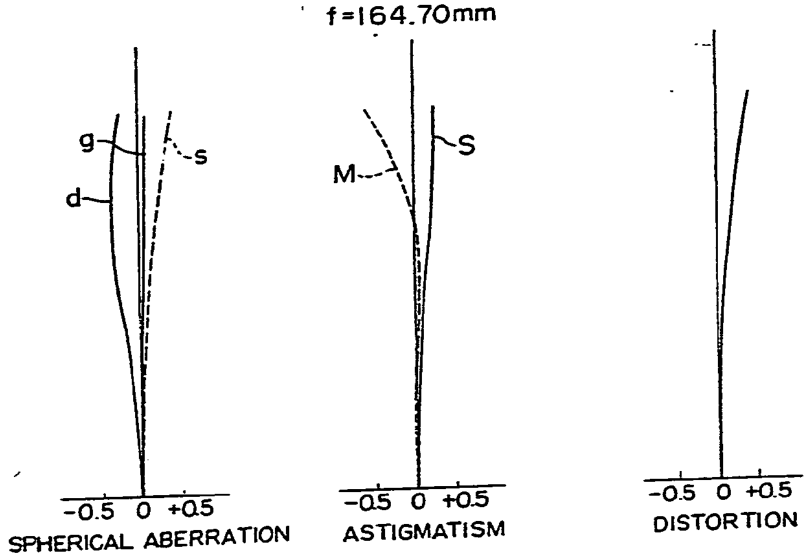


FIG. 3

f=164.70mm



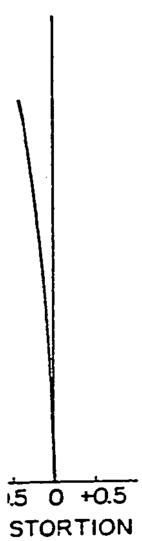
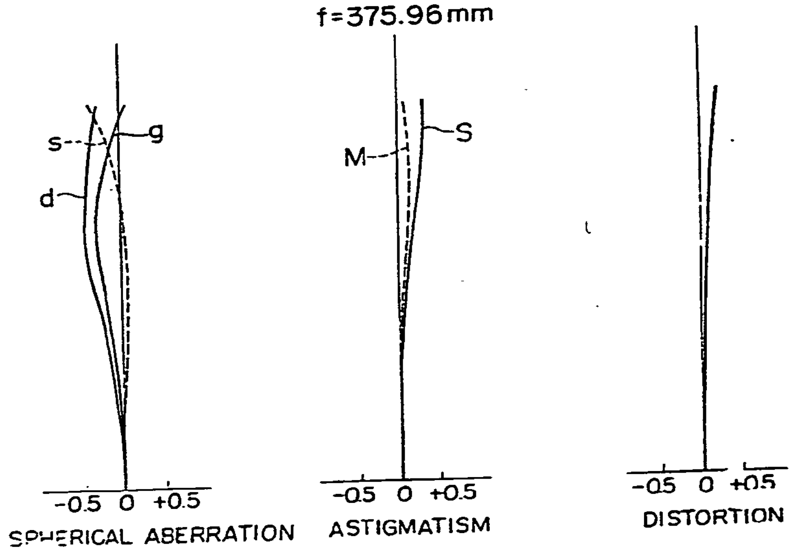


FIG. 4

f=375.96mm



1126069 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 1 & 2

FIG. 1

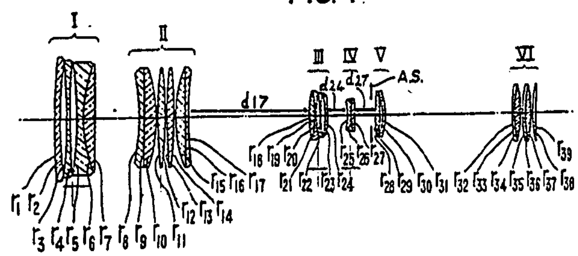


FIG. 2
f = 39.5mm

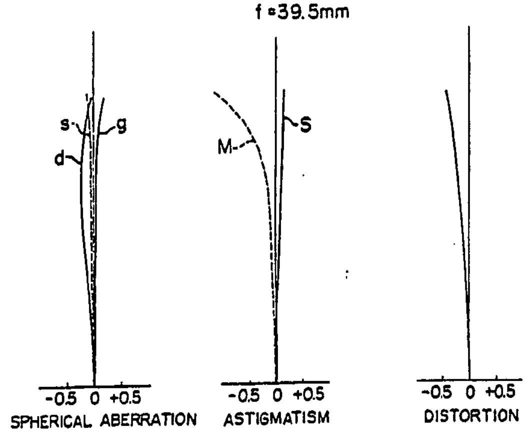


FIG. 3
f = 164.70mm

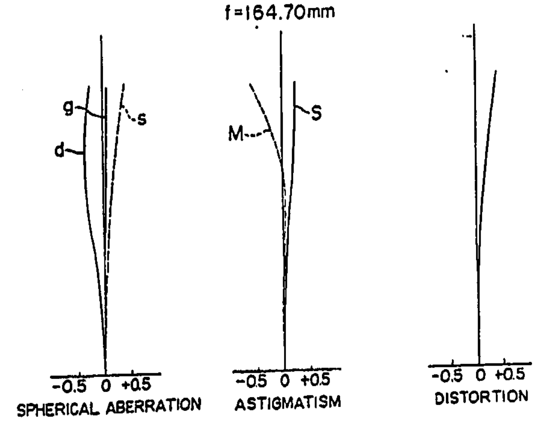


FIG. 4
f = 375.96mm